

Mission Summary

Hurricane Floyd

Winds At Landfall
990916H Aircraft: N42RF

<i>Scientific Crew:</i>		<i>Aircraft Crew:</i>	
<i>Chief Scientists:</i>	Sam Houston, Peter Dodge	<i>Cockpit:</i>	CAPT Dave Tennesen, LCDR Brian Taggart, LCDR Tim O'Mara,
<i>Cloud Physics:</i>	Mark Croxford	<i>Flight Engineers:</i>	Greg Bast, Rock Torrey
<i>Radar/</i>	Peter Dodge	<i>Navigator:</i>	LT Carl Newman
<i>Dropsonde:</i>			
<i>Workstation:</i>	Paul Leighton	<i>Flight Director:</i>	Stan Czyzyk
<i>Air-Sea</i>	Mark Croxford	<i>Engineers:</i>	Jim Roles, Sean McMillan, Juan Carlos Prada-Bergnes, Mark Rogers
<i>Interaction:</i>			
<i>SFMR,</i>	Jim Carswell	<i>Observer:</i>	Vince Cappella (USA Today)
<i>Scatterometer:</i>	(UMASS)		

Mission Briefing:

Initial planning for a Winds Near Landfall mission into Hurricane Floyd began when Florida's central east coast was considered a likely target for landfall. It later became evident that a large trough approaching from the west would likely cause Floyd to turn northward away from Florida. The Carolinas were threatened by Floyd nearly two weeks after Hurricane Dennis (Dennis turned out to sea after closely approaching the southeast coast; Dennis later made landfall in North Carolina as a tropical storm after it had meandered offshore for several days).

The advanced planning for the Floyd landfall mission was no less difficult than in previous cases. The fact that Dade County was in a hurricane warning and AOML was evacuated made this task even more difficult. Nearly all planing had to be done from NHC and Tampa. The NOAA P3's were put on alert for potential landfall missions to take place on the afternoon of 15 September or the morning of 16 September. It became evident on the morning of 15 September that Floyd would remain offshore until very early on 16 September. Therefore, N43RF was used in an Air-Sea experiment in Floyd offshore from South Carolina near the Gulf Stream. At the end of this experiment, some Winds Near Landfall segments were also flown along the North and South Carolina coastline. This mission complemented closely the tasks of our NOAA 42 flight as Floyd made landfall.

Ground-based teams from Texas Tech, NSSL, and the University of Oklahoma deployed three 10 m meteorological towers, three mobile mesonets, and a single Doppler on Wheels (DOW) to study the wind field of Floyd as it made landfall (Table 1). The mobile mesonet teams were able to gather near surface measurements in Floyd's eye and eyewall. All of these field teams had been located in central Florida when that area was threatened the day before. They made an early exit northward, but ran into problems obtaining fuel for their vehicles, especially in Georgia, which was under a hurricane warning (a team from Clemson University, which was in south Florida, was unable to reach North Carolina in time to set up for Floyd's landfall).

Mission Synopsis:

When it became evident the morning of 15 September that Floyd was accelerating northward and would likely make landfall in the Carolinas early on 16 September, the scheduled take off time for N42RF's mission was moved from 0400 UTC to 0300 UTC. Sam Houston and Mark Croxford drove to Tampa from the TPC to meet the other HRD crew members, Peter Dodge and Paul Leighton. The mission briefing took place at 0100 UTC 16 September at Tampa International airport where N42RF was located. At that time, the pilots expressed concern about operating over land where mesovortex signatures had earlier been reported north of Floyd. A tornado watch box extended along the coast from Charleston to Morehead City, and tornados had been reported on the Outer Banks that afternoon. Therefore, the over land portion of the flight plan was eliminated. The remaining portions of the landfall experiment were briefed, which included an initial "figure 4", a series of coastal patrols and a box pattern. The flight legs had radials in conjunction with the KLTIX and KMHX WSR-88D's and the DOW. In addition, GPS dropwindsondes (hereafter referred to as sondes) were launched near university tower sites and NDBC platforms and AXBT deployments were made. The proposed flight track provided to the Flight Director, Stan Czyzyk, is shown in Fig. 1. The flight-level chosen was 8000 ft and the Air Force Reserves WC-130 operating in the area was flying at 10,000 ft.

We took off from Tampa International airport at 0316 UTC and arrived at our IP at 0433 UTC. Enroute, Frank Marks hailed us on the radio from N43RF and provided a useful summary of details about his mission, which had been quite successful. He indicated that Floyd's center was still offshore, so our proposed flight pattern appeared to be on target (see the actual flight track in Fig. 2). We made our first sonde drop near NDBC buoy 41004 at 0441 UTC, where winds were near 34 m s^{-1} at the surface (see Table 2 for a list of sondes dropped). As we arrived from the south of Floyd, the radar reflectivities indicated an ill-defined and "ragged" south eyewall (Fig. 3) even though the infrared satellite image near landfall still looked impressive (Fig. 4). We passed through the flight-level circulation center at 0506 UTC (see Table 2 for center fixes) and could see more vigorous convection in the northern eyewall on radar. We proceeded northeast through this convection on a radial toward the KMRX radar site. In addition to the sonde drops between buoy 41004 and the turn near KMRX, we dropped 4 AXBT's with good data (see Table 4 for AXBT drop locations). After this, we turned to the left at the beach and flew a coastal patrol from near KMRX to Cape Fear. We dropped sondes at 4 locations in the onshore flow along this course, including near the DOW site at Topsail Beach. We made another pass through Floyd's center while it was still a few miles south of Cape Fear at 0556 UTC before circling in the eye and returning on a course that would take us into a coastal patrol from Cape Fear to Myrtle Beach, SC. Three good sondes were dropped in the offshore flow during this portion of the coastal patrol (these were offshore from the TTU tower near Holden Beach, Grand Strand General Airport, and the Myrtle Beach Jetport). By the time we had returned to Floyd's eye at 0630 UTC, it's circulation center was over Bald Head Island at Cape Fear, NC (this was landfall).

We then flew the beginning of the first box east of Floyd over the FPSN7 C-MAN site where we dropped a sonde and then east toward our next turning point near $33.5 \text{ N } 76.5 \text{ W}$ at 0700 UTC (see Fig. 2). We proceeded north from there toward the Cape Lookout (i.e., CLKN7) to drop a sonde at 0710 UTC. Unfortunately, all of the AXBT's we dropped along the east and northbound legs of the box failed. We flew toward the DOW location and dropped a sonde before

passing through the eye, which was 3 miles inland from Wrightsville Beach, NC at 0728 UTC. We then returned to FPSN7 to start the new box (no sonde winds). Our next AXBT drop near our turning point 33.5 N 76.5 W failed again, but we had a good sonde drop here at 0751 UTC. Our next leg to CLKN7 was uneventful and we dropped a sonde here at 0808 UTC. As we approached the DOW site again, the eyewall appeared on radar as a southwest to northeast oriented feature with its cells appearing to be more convectively active than earlier. Prior to the fifth pass through Floyd's eye at 0823 UTC, we dropped two more sondes. The last box began after we left the eye and dropped our last sonde at FPSN7 and CLKN7 during this box. We also launched a successful AXBT during this box. We were also fortunate to have a good AXBT drop this time near our turning point. Our last portion of the box after CLKN7 involved two more sonde drops in the onshore peak winds region and two more south of the eye in the offshore winds region. We made two more penetrations into Floyd and then proceeded home via Buoy 41004. Our landing after a very successful mission was at MacDill AFB at 1136 UTC.

Evaluation:

The mission was very successful and met nearly all of our objectives. We had good luck with Floyd's eye being located offshore for our first two penetrations. This gave us time to complete most of the legs of a modified "figure 4" and a coastal patrol before the circulation center crossed the coastline. The real-time flight-level data adjusted to the surface plus the SFMR data from the previous mission by N43RF were used in the HRD surface wind analysis provided to the forecasters at NHC for 0700 UTC (Fig. 5) The sondes dropped in the storm are plotted in Fig. 6 and listed in Table 3. The boundary layer measurements from the sondes appear to have been good in most cases, especially near the coast and C-MAN stations. It is believed that we will have an excellent data set for analysis using the flight-level winds from N42RF, the Air Force reconnaissance flight, and the sondes. The near surface and surface winds should also be available from sondes, the SFMR, and the scatterometer for documenting Floyd's winds in the offshore and onshore flow near the coast.

Acknowledgments:

Paul Leighton was very helpful in assisting Peter Dodge with drawing up the flight plan to meet the FAA deadline. Mark Croxford provided excellent notes from the mission and was a valuable asset on board. Special thanks to Hugh Willoughby, Peter Black, and Steve Feuer for providing guidance on Floyd's whereabouts and projected track prior to our mission. The AOC crew also very helpful during our mission despite the late hours it required us to be flying and working. We especially appreciate the early start (shortly after 0300 UTC instead of 0400 UTC) take off that allowed us enough time to arrive on station for our mission before Floyd moved inland. Sam Houston was contacted by Steve Delgreco of NCDC and Rainer Dombrowsky of the ASOS Program Office about turning on hi-res ASOS data for states which might be affected: Florida, Georgia, and South Carolina were requested (unfortunately North Carolina was later put under a warning and the hi-res data retrieval may not have happened at all such sites here). Reid Hawkins, SOO at the Wilmington NWSO provided hi-res ASOS data for ILM and CRE.

Problems:

The radar system froze briefly a few times during the flight, but not in mission critical regions. Three of the AXBT's failed in the box pattern east of Floyd, but our last one provided good data. A few sonde failures occurred, but there did not seem to be an unusually large percentage of failures. No known problems with data gathered by existing or special platforms in North and South Carolina were reported at the time of this writing.

Sam Houston and Peter Dodge
9/28/99

Table 1: Locations of University 10 m meteorological tower deployments. A DOW was also located at the Topsail Beach location. Mobile mesonets operated in the Cape Fear area of southeastern North Carolina.

Tower location	Latitude (N) (deg min)	Longitude (W) (deg min)	University
Southport Airport	33 55	78 15	Texas Tech
Wilmington Airport	34 16	77 55	Texas Tech
Topsail Beach.	34 23	77 39	University of Oklahoma tower and DOW

Table 2: Center fixes for Floyd from N42RF and the Air Force (AF) on 16 September (*Landfall occurred over Bald Head Island at Cape Fear). Sea level pressures (slp) were provided in some Air Force eye drops.

Time (UTC)	Latitude (N) (deg min)	Longitude (W) (deg min)	Aircraft
0500	33 26	78 13	AF
0506	33 26	78 10	N42RF
0556	33 47	78 06	N42RF
0609	33 41	78 02	AF (slp = 957 mb)
0630*	33 51	77 59	N42RF
0645	33 59	77 58	AF (slp = 956 mb)
0728	34 12	77 48	N42RF
0823	34 20	77 37	N42RF
0916	34 26	77 29	N42RF
0928	34 28	77 28	AF
0930	34 41	77 26	N42RF

Table 3: Splash locations of sondes launched during the Floyd mission. Here MBL = mean boundary layer wind (fffdd; fff = wind direction in deg and dd = wind speed in kt), LST WND = height of last wind (meters), and SST = sea surface temperature (deg C). Sonde 26 was sent after all the others. Sondes 2, 10, and 29 had no winds (these were not transmitted), but the P, T and RH may be available. Sonde 17 had no launch detect, but these data may be recoverable later, if the sonde id can be determined.

#	sonde id	time (UTC)	Lat. (°N)	Lon (°W)	comments
1	991845148	0441	32.47	79.08	MBL WND 32072 LST WND 011
2	990935168	0502	33.28	78.43	no winds
3	991435107	0514	33.89	77.77	MBL WND 10084 LST WND 011
4	991515138	0514	33.90	77.75	MBL WND 10582 LST WND 013 EYEWALL 045 SST 260
5	991845159	0533	34.70	76.97	MBL WND 11552 LST WND 014
6	991515166	0539	34.46	77.39	MBL WND 11563 RAINBAND
7	990935144	0545	34.19	77.70	MBL WND 09576
8	990935054	0552	33.86	77.90	MBL WND 12581
9	990935114	0606	33.82	78.28	MBL WND 35575
10	990935050	0611	33.70	78.68	no winds
11	991515241	0612	33.59	78.77	MBL WND 33584 LST WND 083
12	990935146	0614	33.47	78.91	MBL WND 33074
13	990935145	0638	33.53	77/53	MBL WND 20566 SST 264
14	990415360	0640	33.40	77.40	MBL WND 22580
15	990415375	0644	33.36	77.10	MBL WND 21073
16	990935048	0710	34.68	76.57	MBL WND 13569
17	missing	0722	34.42	77.48	no launch detect
18	992455395	0722	34.43	77.61	MBL WND 10088 LST WND 108 EYEWALL 045
20	990935112	0751	33.30	76.53	MBL WND 20064
21	990845100	0808	34.68	76.55	MBL WND 14574
22	990935116	0819	34.55	77.34	MBL WND 13093
23	991515161	0821	34.47	77.47	MBL WND 13572 LST WND 011
24	990935135	0837	33.45	77.47	MBL WND 26557
25	991515191	0904	34.69	76.68	MBL WND 15087
26	991515194	0909	34.67	76.99	MBL WND 15077 LST WND 028
27	990935215	0912	34.64	77.22	MBL WND 14568
28	990415352	0922	34.14	77.70	MBL WND 30082
29	991018021	0923	34.10	77.82	fast fall sonde

Table 4: Locations of AXBT's launched during the Hurricane Floyd mission and SST (°C).

#	time (UTC)	Latitude (N) (deg min)	Longitude (W) (deg min)	comments
1	0453	33 07	79 04	Near 41004, failed
2	0502	33 17	78 26	SW eyewall, good, SST=25.0
3	0514	33 52	77 40	NE eyewall, good, SST=26.0
4	0522	34 14	77 13	50 km NE of 3, good, SST=26.0
5	0638	33 29	77 34	E of Floyd, good, SST=26.4
6	0652	33 17	76 32	failed
7	0700	34 03	76 31	failed
8	0751	33 16	76 32	failed
9	0848	33 17	76 33	SE of Floyd, good, SST=29.0

Figure 1: Proposed flight-track based on the best estimate of Floyd's position at the expected time of N42RF's initial arrival into the hurricane's core. Shown are NDBC and University team's platform locations, along with the WSR-88D sites in North Carolina (range rings indicate radar reflectivity and Doppler data availability).

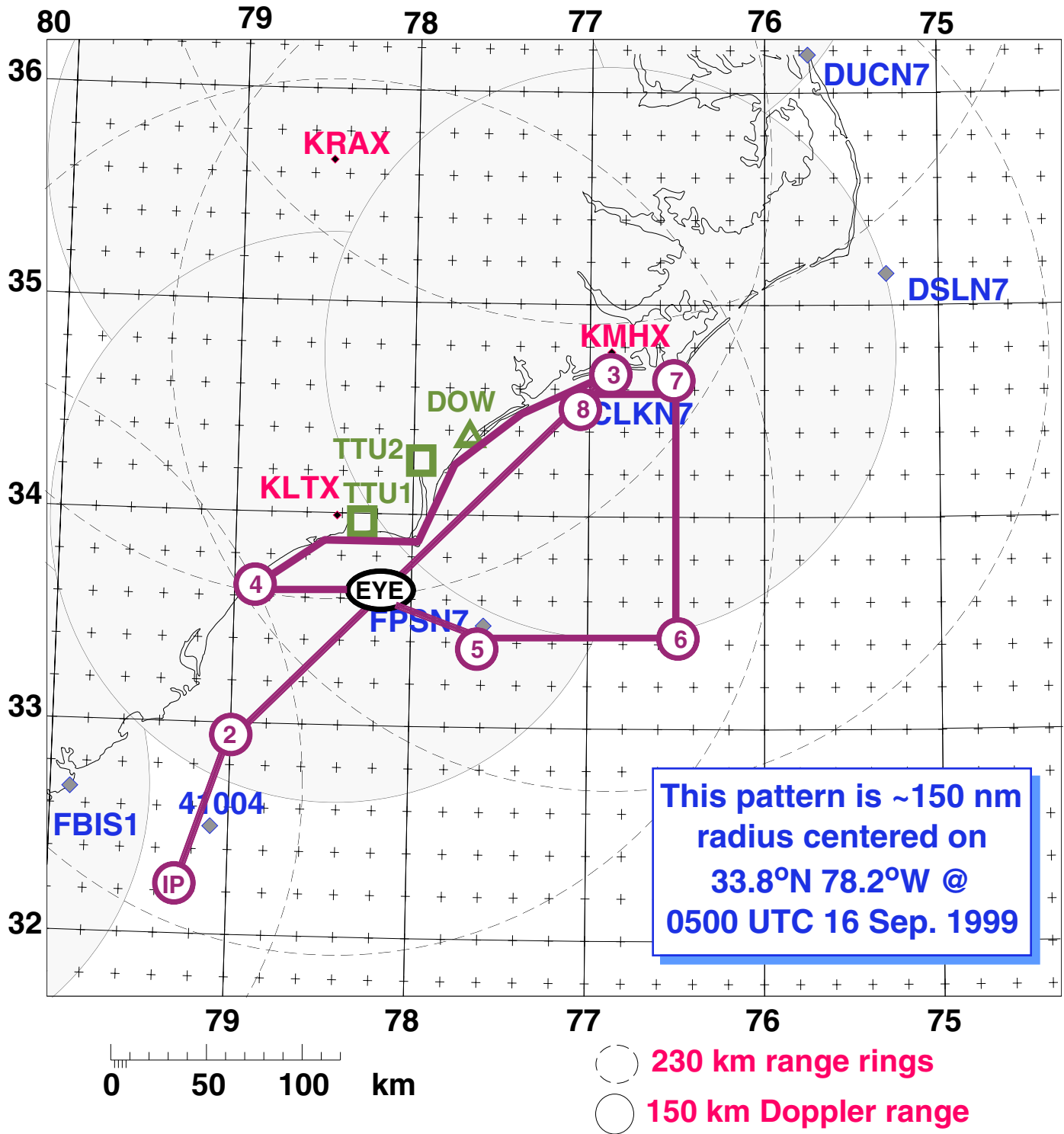
Figure 2: Actual flight track flown with surface platforms and Hurricane Floyd's storm track during the mission shown.

Figure 3: Composite of real-time lower fuselage radar reflectivities (dBZ) shown for 0445 to 0514 UTC.

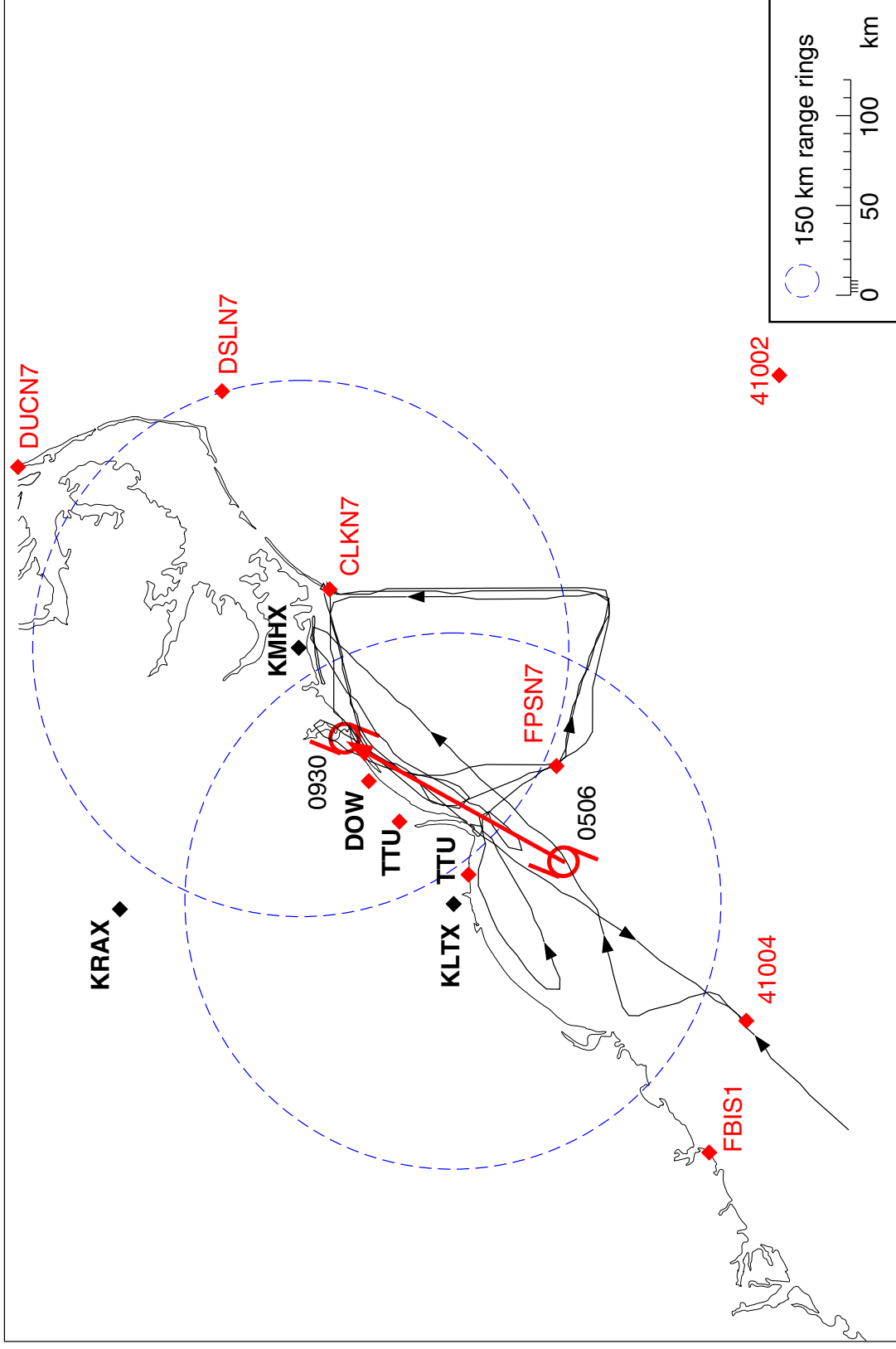
Figure 4: GOES-8 IR satellite image of Floyd soon after landfall.

Figure 5: HRD surface wind analysis provided to the forecasters at for Hurricane Floyd for 0700 UTC 16 September 1999.

Figure 6: Locations of the sondes with good data during the Hurricane Floyd Winds at Landfall mission.



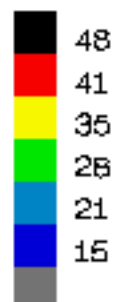
NOAA 42 Hurricane Floyd Landfall flight 16 September 1999 0400-1020 UTC



990916h1

FLOYD

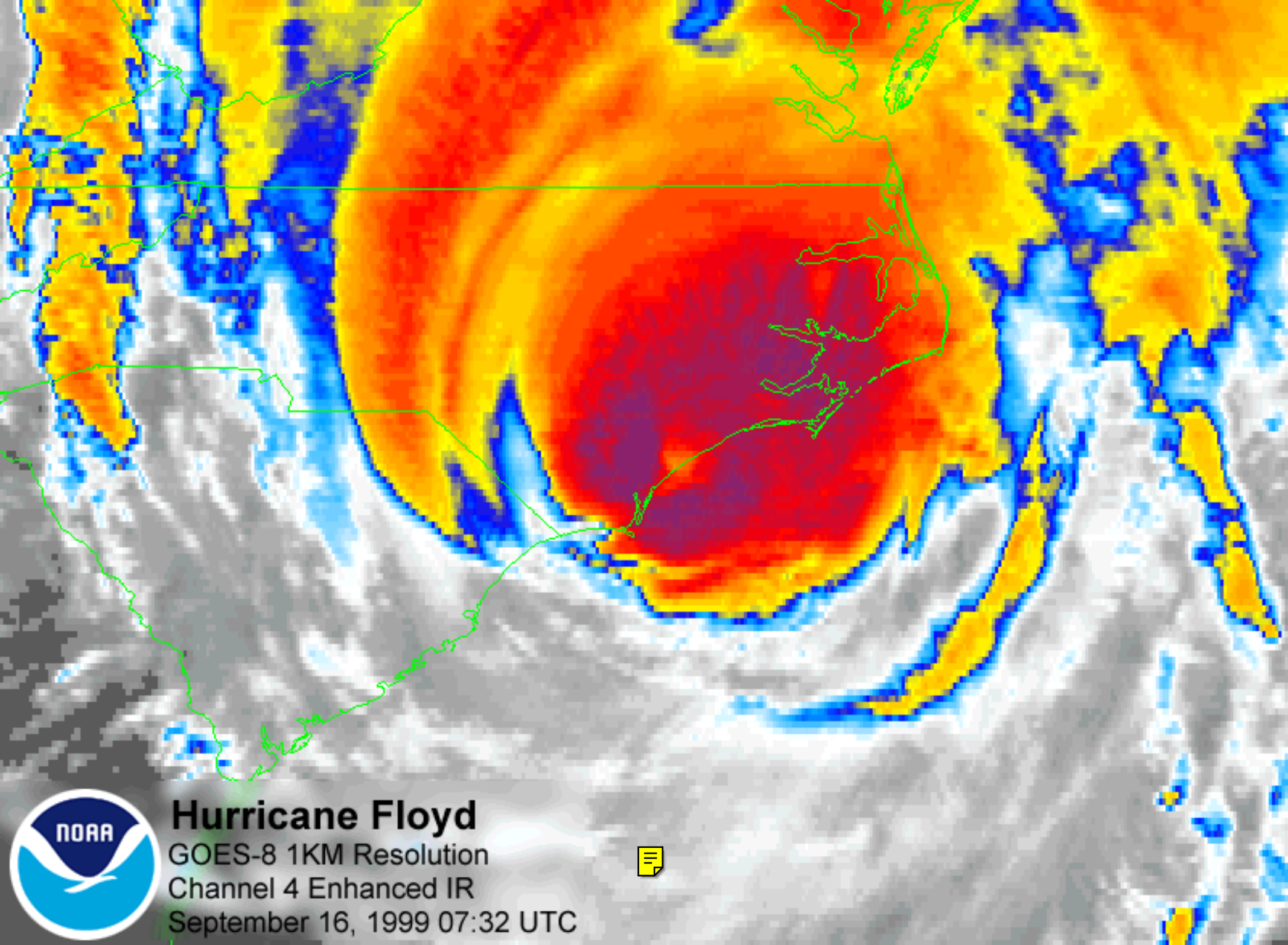
044522 Z to
051448 Z



dBZ Slat 33.50 N
Slon 77.86 W

360 X 360 km

produced by
HRD / AOC



Hurricane Floyd

GOES-8 1KM Resolution

Channel 4 Enhanced IR

September 16, 1999 07:32 UTC



ATTENTION: HURRICANE SPECIALISTS

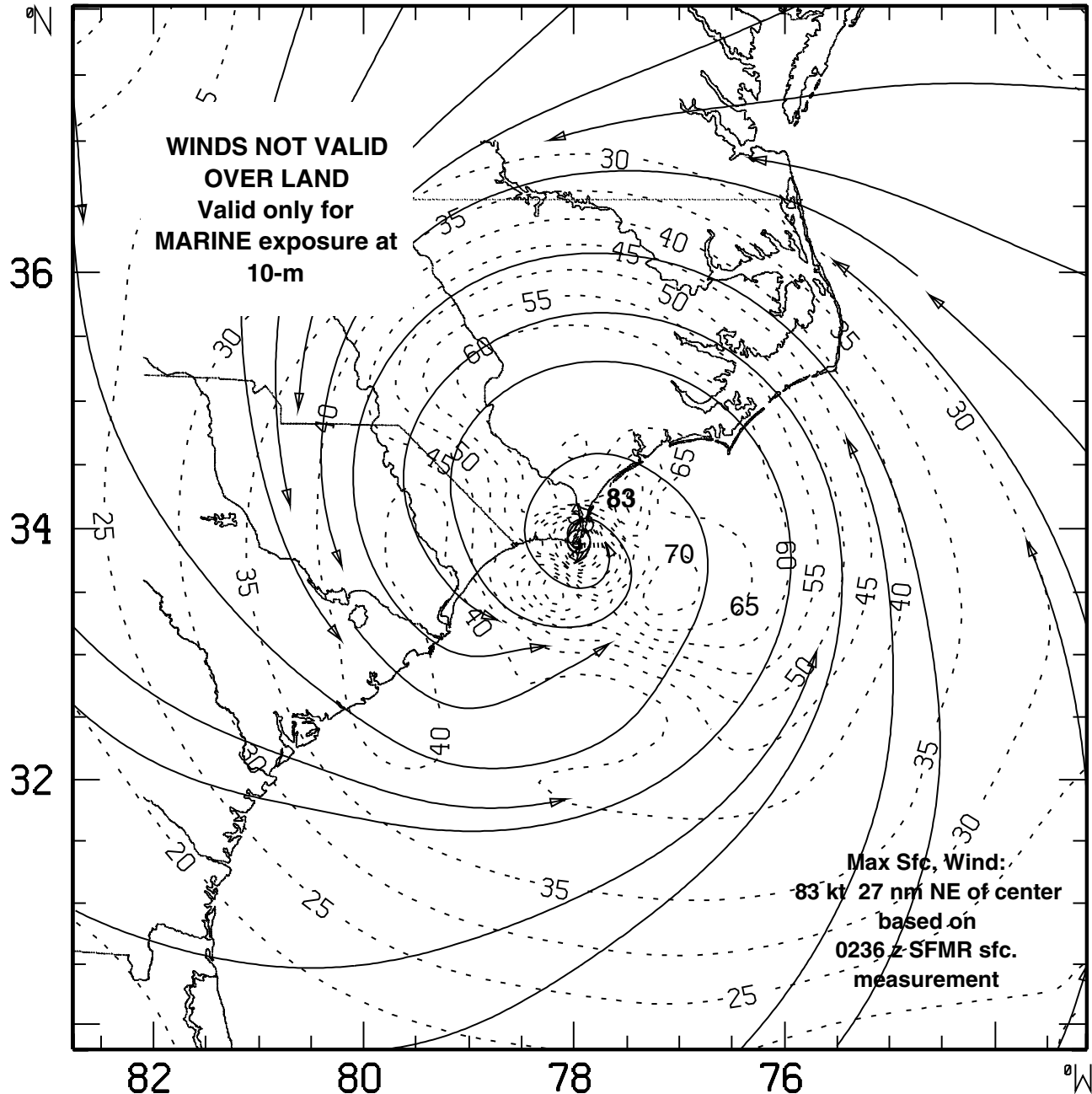
Hurricane Floyd 0700 UTC 16 Sept. 1999

Max. 1-min sustained surface winds (kt) for marine exposure

Analysis based on Selected NOAA 43 SFMR Measurements: 0229 - 0456 z,
NOAA 43 and 42 aircraft 2500 m level winds adj. to sfc. from 0229-0630 z.

Buoy, C-MAN, and ship reports from 0300-0600 z,

0700 z position extrapolated from 0609 z wind center fix using 020° @ 16 kt, mslp = 956 mb.

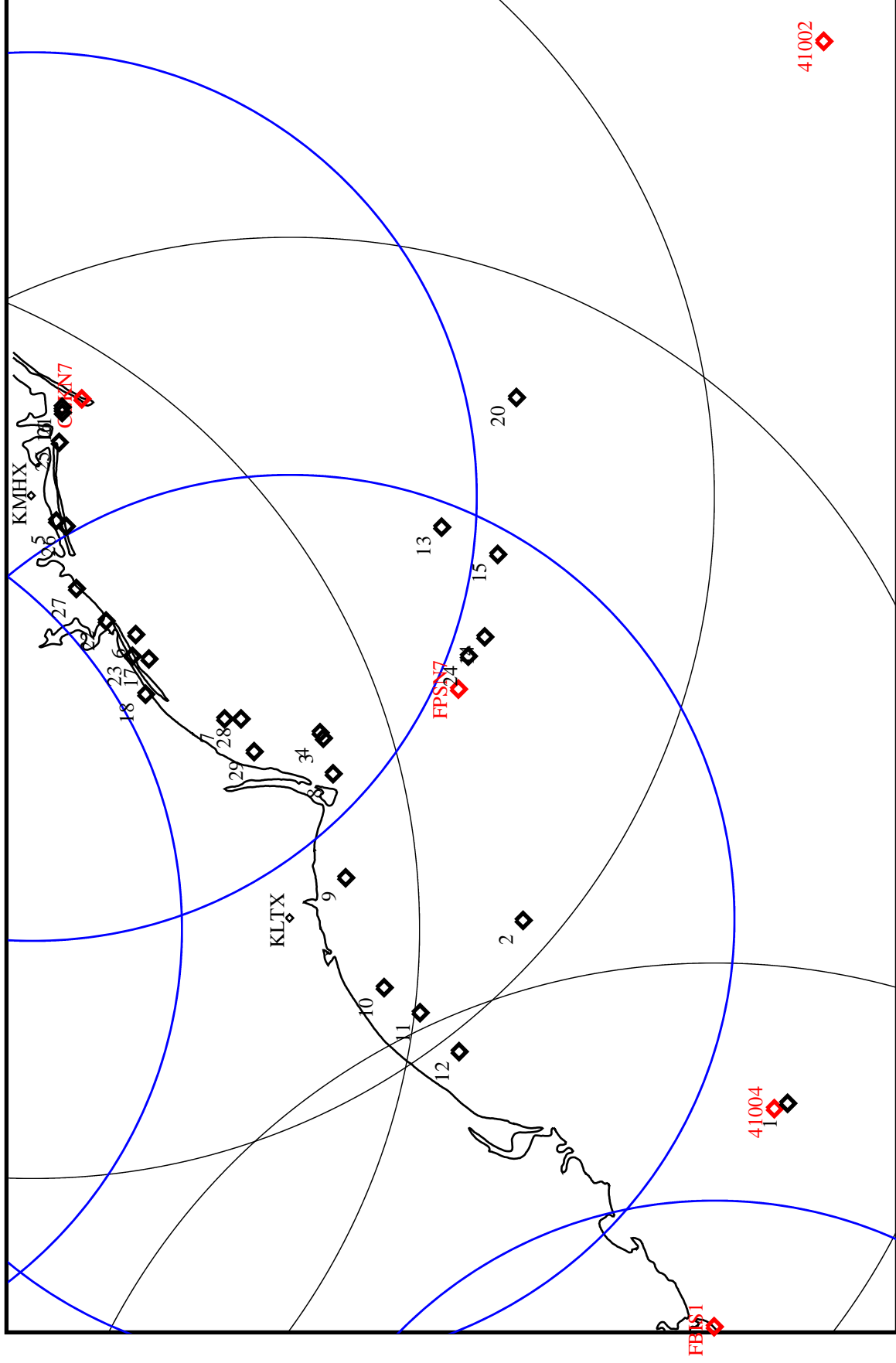


Experimental research product of :

NOAA / AOML / Hurricane Research Division



Center Lat: 33.50 Lon: -77.50



230 km range rings
150 km haze rings

0 50 km